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LIFE CYCLE OF THE FRESHWATER SNAIL *CAMPELOMA DECISUM* (VIVIPARIDAE) IN THE LABORATORY

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ABSTRACT

Campeloma decisum *reared in Minnesota Lake Superior water grew consistently well when clam meat or commercial fish food was provided and a substrate of sand or mud was present. Food alone, or the substrate alone, was generally ineffective in promoting growth. Thick substrates were more effective than thin substrates. Substrate depth was directly correlated with growth, although some growth occurred when no soft substrate was present.* Campeloma decisum *tested in Missouri hard well water grew equally well with or without a substrate. A population of newborn snails from the St. Croix River, Wisconsin was reared through three generations in 42 months on a diet of clam meat and trout chow with St. Croix River mud substrate. Survival of the original snails to 41 months was 80%.*

Campeloma is an exclusively North American genus of ovoviviparus snails widely distributed in lakes and streams of eastern North America. *Campeloma decisum* (Say, 1819) plays an important role in the fish (Price, 1957) and diving duck (Thompson, 1973) food chains and has been used in studying the effects of toxicants in the laboratory (Arthur, 1970, Arthur and Leonard, 1970).

Arthur and Leonard (1970) studied the effects of a range of copper concentrations on survival, feeding and parturition of young *Campeloma decisum* snails. The snails completely devoured fresh unionid clam meat in copper concentrations of control (2.0 μg/l) up to 8.0 μg/l but would not accept or consume this food at the higher concentrations tested. Although the control snails fed at the rate of one clam per 10 snails per week, there was no measurable growth in 6 weeks. Thus, it was not possible to assess the effects of copper on the ability of the snails to grow and complete the life-cycle. It was believed that experiments to determine why the snails fed without growing would demonstrate a way to grow the snails in the laboratory.

A literature review suggested several explanations for why the snails fed without growing. The following describes several experiments which tested these ideas and ultimately culminated in rearing *Campeloma decisum* through several generations in the laboratory.

Allison (1942) trapped *Campeloma* with dead

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fish or cloth packets of dog, cat, chicken, ferret or muskrat dung. Snails came from both up and down stream, with a maximum number of snails at the trap on the 10th day. Bovbjerg (1952) found populations of *Campeloma decisum* just downstream from rapids in the presence of silt and detritus. In the absence of factors that would orient the snails to food, the snails moved upstream (positive rheotactic response) but the hard surfaces associated with riffles or rapids blocked further upstream movement. Snails moving upstream did not travel over exposed surfaces of rocks. Snails also aggregated on the downstream side of log barriers or boulders.

Thus, the literature reports that *Campeloma decisum* feeds on decayed animal material and cannot function properly on a bare hard surface. In the following experiments *Campeloma decisum* was fed dead clams or other foods under various conditions of hard, sandy, muddy or other substrates. Water quality was also varied to determine the significance of hardness, calcium, or other minerals in growth.

MATERIALS AND METHODS

Effect of Substrate and Food Source

In a study to determine if a soft substrate is needed for growth of snails, young *Campeloma decisum* and various substrates were collected from the St. Croix River, Douglas Co., Wisconsin where the calcium content was 32–37 mg/l as $CaCO_3$. Tests were run for 90 days in flowing carbon filtered water pumped from Lake Superior at Duluth. During the tests, calcium was 46–53 mg/l as $CaCO_3$, temperature 18±1C, dissolved oxygen 8.2–10.2 mg/l, and pH 7.5–8.0.

Ten or 20 snails as available were randomized by size and added to each of 48 10-liter tanks. Substrates provided were either mud or sand, 3.5–4.5 cm deep. Other snails were held in tanks with only glass substrates. Either one 10–15 cm long freshly killed unionid clam or 0.5 gram trout chow (Glencoe starter granules) was provided every 1–2 weeks. Shell lengths were measured with vernier calipers (0.1 mm accuracy).

Tests with Missouri Snails in Hard Water

To determine further if a soft substrate was needed for growth of snails tested in hard water, young *Campeloma decisum* were collected from a muddy substrate in the Gasconade River, Osage Co., Missouri.

Sandy substrate (with some silt and gravel intermixed) was collected from a Gasconade tributary and a layer of this substrate 2.3 cm thick was added to four aquaria each containing 10 snails and 10.3 liters of Columbia, Missouri hard well water (Ca, 70; Mg, 27; K, 3.9; SO_4, 4.4; Cl, 29; EDTA hardness, 272 mg/l).

The water was continuously exchanged at the rate of 0.50–0.52 liters every 4–8 minutes. Four additional control aquaria differed in that no substrate was added to the glass bottom. One dead 10–12 cm freshwater mussel was fed every 3 weeks to the snails in each of two substrate and two control aquaria. This experiment ran from June 19–September 9, 1978 at 18.5–19.3C.

Campeloma Life Cycle

Adult snails were collected in February, 1970 from the St. Croix River, Douglas Co., Wisconsin and placed on a sieved mud substrate in an aquarium at the Duluth Environmental Research laboratory. In August 1970, 30 newborn snails were recovered from this aquarium and placed in an aquarium with sieved mud substrate 3.5–4.5 cm thick. They were fed trout chow with clam meat ad libitum. The snails were provided with flowing Lake Superior water at 18±1C. The mud substrate was exchanged in March 1971, June 1973, and January 1974. Growth rates of the young snails were measured periodically.

RESULTS

Campeloma decisum tested in Duluth, Minnesota soft water grew consistently well when clam or fish food was provided and a substrate of sand or mud was present (Table 1). For example, in one tank with glass substrate and clam meat growth was 0.3 mm (standard error of only 0.09) in 90 days. With mud substrate and clam meat the least growth was 0.8 mm. Food alone, or the substrate alone was generally ineffective in promoting growth. The most growth with mud alone was 0.7 mm. Thick substrates were more effective than thin substrates (Table 2). It

TABLE 1. *Growth in 90 days of* Campeloma decisum *snails (10–20 mm original length) in varied substrates and food sources. Duluth soft water. Each number (except overall average) is average growth (mm) of 10 or 20 snails.*

Substrate provided	FOOD SOURCES None	Clam	$S_{\bar{x}}$	Fish Food
Glass	0.0	0.0		0.1
		0.0		0.2
		0.1		0.2
		0.1		0.2
		0.2		0.7
		0.3	0.09	0.8
		0.4		1.0
		0.6		2.0
		0.8		
		1.0		
		1.2		
		0.4	0.05	0.65
Mud	0.0	0.8	0.25	2.1
	0.0	0.9	0.12	
(St. Croix River)	0.0	1.0	0.25	
	0.1	1.0	0.19	
	0.1	1.1	0.28	
	0.1	1.3	0.33	
	0.1	1.3	0.31	
	0.2	1.3	0.15	
	0.2			
	0.3			
	0.7			
	0.16	1.1	0.079	
Sand	0.1	0.7	0.17	
	0.1	0.7	0.22	
(St. Croix River)	0.0	0.9	0.23	
		1.0	0.21	
		1.3	0.33	
	0.07	0.9	0.10	

TABLE 2. *Growth in 90 days of* Campeloma decisum *snails (10–20 mm original length) in varied St. Croix River mud substrate depths and food sources. Duluth soft water. Each number is average growth (mm) of 10 snails.*

Substrate provided	FOOD SOURCE None	Clam	$S_{\bar{x}}$	Fish Food	$S_{\bar{x}}$
Glass	0.0	0.5		1.5	
	0.0	0.5		1.1	
	0.0	0.7		1.1	
		0.57	0.098	1.23	0.10
1.0 mm	0.0	1.2		2.8	
	0.0	1.5		1.5	
	0.0	1.1		1.8	
		1.27	0.11	2.0	0.17
5.0 mm	0.0	1.8		3.3	
	0.0	1.3		3.4	
	0.0	1.4		3.2	
		1.5	0.15	3.3	0.26
25.0 mm	0.0	2.1		3.2	
	0.0	2.2		3.7	
	0.0	2.5		2.6	
		2.27	0.17	3.17	0.17

TABLE 3. *Growth of young Missouri snails June 9–September 19. Missouri hard water. 18.5–19.3C.*

Substrate	Food	Initial No.	Initial length	mm growth 102 days	$S_{\bar{x}}$	Final No. Alive
Sand	none	10	10.4 - 12.9	0.0		10
"	"	10	13.2 - 15.8	0.0		10
Glass	none	10	8.7 - 12.0	0.0		10
"	"	10	12.8 - 15.0	0.0		10
Glass	clam	10	9.7 - 12.9	2.0	0.34	10
"	"	10	13.7 - 16.0	2.3	0.38	9
Sand	clam	20	9.8 - 16.2	2.4	0.27	12

TABLE 4. *Mean length and number of survivors for several generations of* Campeloma decisum. *The first generation produced at least three second generations. The first of these in turn produced a third generation.*

Date	First Generation			Second Generation			Second Generation			Second Generation			Third Generation		
	N	Age (months)	length (mm)	N	Age (months)	length (mm)	N	Age (months)	length (mm)	N	Age (months)	length (mm)	N	Age (months)	length (mm)
August 1970	30	0	newborn												
January 1972	29	17	18.3	27	0	3.5									
January 1973	28	29	23.1												
March 1973				21	14	10.9									
September 1973	27	37	23.7	14	20	17.4	30	6	7.0						
January 1974	24	41	24.4	15	24	18.8	30	10	9.0	30	3	4.9			
February 1974													34	0	3.5
June 1974	17	46	25.1	15	29	20.9	30	15	13.6	29	8	7.0	10	4	4.5

is seen that substrate depth was directly correlated with growth, although some growth occurred without any soft substrate. The survival rate was 80–100% per tank.

Campeloma decisum tested in Columbia, Missouri hard water grew equally well with or without substrate (Table 3). A population of newborn snails from the St. Croix River, Wisconsin was reared through three generations in 42 months on a diet of clam meat and trout chow with St. Croix River mud substrate (Table 4).

DISCUSSION

The demonstrated synergistic action of food and natural sand or mud substrate on growth of *Campeloma decisum* in the laboratory is probably related to the preference of this species for sand or mud substrate in the wild.

Further experimentation is required to determine if the synergistic property of the substrate was a mineral such as calcium, a vitamin, sand grain digestive aid, protection from harmful wavelengths of light, or a "psychological requirement." It is not known if the lack of synergistic action of soft substrate and food for Missouri snails in Missouri hard water was due to calcium in the hard water or genetic differences from the Wisconsin snail population. Chamberlain (1958) cultured 45 North Carolina

Campeloma decisum "in isolation" in 4.5 inch fingerbowls containing a natural substrate of clayey silt with some sand and decaying organic debris. They grew at about the same rate as in nature but only two snails were still alive after 12 months. He found that *Campeloma decisum* from University Lake, Chapel Hill, North Carolina were not gravid before two years of age and until reaching 15.0 mm in length. The largest snail he collected was 27.3 mm long. The second year class lost identity as a size class at 20 mm in length. The parturition period was from mid-March until the end of June.

Medcof (1940) who studied *Campeloma decisum* from the Speed River, Ontario, also reported that sexual maturity was reached in two years, and one, two, and three year old snails were 12, 17 and 23 mm long, respectively. The parturition period was from March–September. From Table 4 it may be noted that newborn snails (August 1970) reproduced in less than two years (January 1972, about 17 months after birth) presumably due to early parturition in the laboratory. The approximate maximum length (25.1 mm) obtained by snails in our study was similar to that found by Medcof (23 mm) and Chamberlain (20–27.3 mm).

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